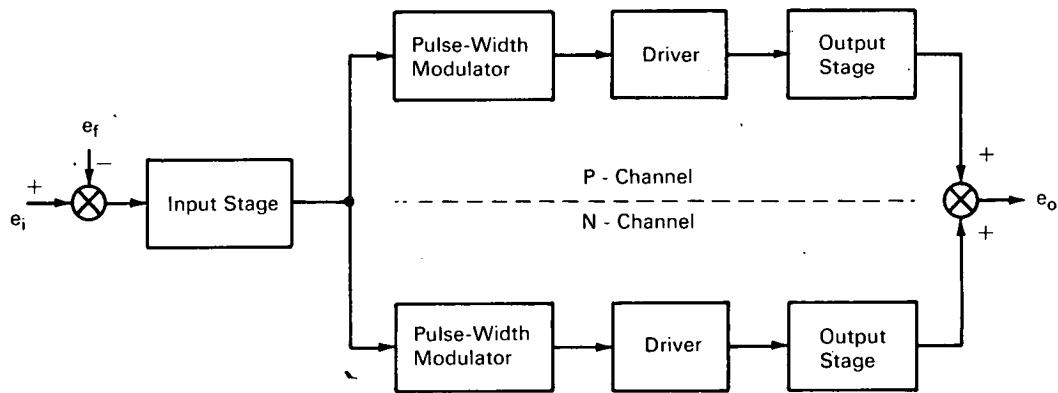


# NASA TECH BRIEF



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## Analysis and Design of a Class-D Amplifier



Switching-mode, or class-D amplification may be used to take advantage of the high efficiency of operating transistors in the saturation region. A theoretical analysis has been made of a basic class-D amplifier circuit configuration, and the results of the analysis have been applied to a specific procedure for the practical design of class-D amplifiers that are readily adaptable to a variety of applications. The theoretical aspects of the basic design are considered with a stage-by-stage analysis of feedback, input and output (load) configurations, and the frequency spectrum of the pulse-width-modulated signal.

The basic class-D amplifier design developed is shown in the block diagram. The input stage is a high-gain operational amplifier with local feedback, connected in such manner that the stage is a noninverting amplifier. The primary function of the input stage is to provide the complete class-D amplifier with a high open-loop voltage gain. In addition, this stage provides a high-impedance input and a convenient means of introducing frequency compensation for stabilization of the complete amplifier. The input stage am-

plifies the difference voltage, a signal proportional to the difference between the input  $e_i$  and feedback  $e_f$  voltages. This signal provides a control voltage to the pulse-width modulator. The modulator, driver, and output stages each have two separate, but similar circuits, referred to as the "P" channel, which responds to positive control voltages and produces negative output voltages, and the "N" channel, which responds to negative control voltages and produces positive output voltages. The polarity of the control voltage determines which channel is to be activated, and the magnitude of the control voltage determines the pulse width produced by the modulator. The pulses generated by the modulator undergo power amplification in the driver stage and are coupled to the output stage, causing the output stage to operate in the switching mode. The high-power pulse signal generated is filtered to provide an analog output voltage,  $e_o$ .

Some of the features possessed by the basic amplifier design presented are: (1) the capability of producing both ac and bipolar dc output voltages (a dc

(continued overleaf)

voltage of either polarity); (2) a maximum power output of several hundred watts, without significant departure from the basic design; (3) overall dc efficiency of 90% at maximum power output, with efficiency remaining relatively high over most of the range of power output; (4) very low quiescent power consumption; and (5) input and output circuitry adaptable to a wide variety of signal sources, loads, and feedback configurations.

**Note:**

Complete details may be obtained from:

Technology Utilization Officer  
Marshall Space Flight Center  
Huntsville, Alabama 35812  
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No patent action is contemplated by NASA.

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